INCREASED CAPABILITIES FOR RASTER SCAN DISPLAYS

Video response to 12 MHz and resolution up to 800 lines are available in production CRT displays. Using the common 5 x 7 dot character array, allowing a two dot horizontal intercharacter space and three blank scan lines of vertical spacing, an 80 x 24 display of 1920 characters is easily attainable with a low cost display monitor. (Figure 1) If more capability is required, such as a 7 x 9 dot character array or more than 24 lines of data, an improved performance display may be needed. Interlaced scan, lower refresh rate, higher line rate or StepScan™ may be used to increase the capability of a display monitor.

INTERLACED SCAN

This is the scanning method used in broadcast television. As implemented in character displays, alternate lines of the character display are reproduced in successive fields. In either application, broadcast television or character display, this results in small elements being displayed at a 30 Hz rate (Assuming a 60 Hz field rate). Since television scene content consists mostly of large white areas, no objectionable flicker is apparent. In character display applications, however, all of the displayed data consists of small elements. Consequently, an annoying flicker results when alphanumeric data is displayed using interlaced scan, unless a long persistance phosphor is used.

PHOSPHOR CONSIDERATIONS

Long persistance phosphors have two undesirable characteristics that must be taken into account. These are: poorer spot definition and increased tendency to "burn". The compromise in spot definition compared to a normal phosphor is due to the method used to increase persistance. Long persistance phosphors generally consist of two components: a phosphor that glows when excited by an electron beam and an "afterglow" component that glows when excited by light. The scattering of light from electron beam excited phosphor granules to the light excited granules results in poorer spot definition. While this loss of definition is not severe, it should be evaluated early in the design of the CRT readout system, since the primary reason for using interlaced scan is to achieve high character counts and thus, high character density.

Long persistance phosphors tend to "burn" as a result of use. This "burn" is a permanent darkening of the phosphor granules and is proportional to the product of beam current and time. If the same message always appeared on, for example, the first line of a display, this message would become burned into the phosphor and could eventually be read even if the display is turned off. Due to the random nature of most displayed data, the phosphor will most likely have each of the character matrices burned in, presenting a pattern of rows of small rectangles. Since the CRT is useful long after phosphor burn appears, the problem is, initially, more aesthetic than critical. Use of a neutral density filter in front of the CRT can make the phosphor discoloration less noticeable to the operator.

In borderline situations where flicker is barely noticeable, a neutral density filter or a lower transmission face plate on the CRT can eliminate the need for a long persistance phosphor. A suitable contrast ratio for viewing is attainable at lower brightness with the filter, and the tendency of the eye to perceive flicker decreases with reduced display brightness.

CHARACTER GENERATOR CONSIDERATIONS

Since interlaced scan displays data at one-half the frame rate, twice as many characters can be displayed at the same clock frequency. This is an advantage where bandwidth is a problem, such as applications that require character video to be carried by long runs of cable.

Because alternate lines of the character display are presented in successive fields, the CRT beam current will not be identical field to field unless an odd line count per character block is used. (Figure 2) If this is not done, variations in CRT anode supply voltage may cause size differences between successive fields, making characters illegible. The field-to-field variations in anode supply voltage can be prevented by increased filtering, but the size and cost of the filter capacitor required make the solution proposed above more attractive.

LOWER REFRESH RATE

Reducing the vertical scan rate from 60 Hz to 50 Hz will add five additional character rows to the format shown in figure 1. Care must be taken to insure that 60 Hz magnetic interference is shielded from the CRT to prevent raster jitter at the 10 Hz beat rate with the 50 Hz sweep. If sweep rates lower than 50 Hz are used, a long persistance CRT may be needed to prevent flicker.

HIGH LINE RATE

Additional lines can be added to a 60 Hz format by increasing the horizontal scan rate. A horizontal rate of 18720 Hz permits an increase of 50 display lines, or 5 rows if a 10 line character block is used. Increases of 19% result both in character and dot rates. Using the

example in the table in figure 1, the result would be a 1.87 MHz character rate and a dot rate of 13.1 MHz. In designs where character video is to be sent to a remote location, the limit for this method of increasing display capability is reached when the clock rate is higher than can be carried by the cable without significant rolloff.

DOT DUTY CYCLE

Character video can be sent over longer runs of cable without distortion if character dots are displayed for 50% of the clock period instead of 100% (Figure 3). The cable path and video amplifier should have a nearly flat bandpass over a five to one range to present characters of uniform brightness over the entire character if 100% dot duty cycle is used. This is because vertical character lines have higher frequency components than horizontal lines. To present uniform brightness characters when chopped (50%) duty cycle dots are used, the system need only have sufficient gain and bandwidth without peaks to drive the CRT.

STEPSCAN^{TM}

The format described in Figure 1 allows only one line space between the cursor and the top of the next character row. If an additional three lines were required to give the text a less crowded appearance, a 30% increase in both character and dot rates would result, making these 2.04 MHz and 14.3 MHz respectively.

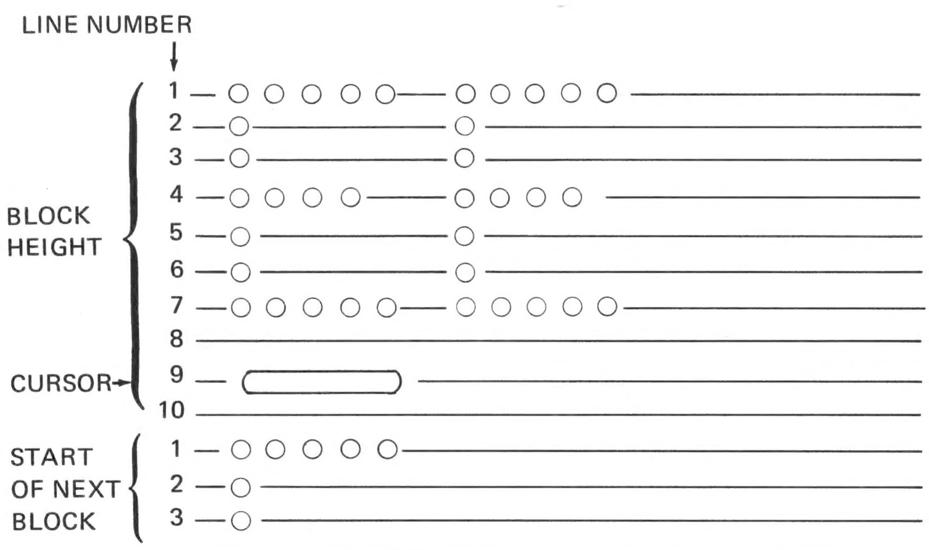
Desired vertical character spacing can be obtained by speeding up vertical scan during one horizontal line. This can provide four or more lines of vertical intercharacter space in one line time with no increase in character or dot rates (Figure 4). To implement this, modified vertical sweep circuitry is required and an additional input must be provided to the monitor to identify the line to be stretched.

CONCLUSION

Generally, the video monitor that provides the most performance per dollar with reliability is one that can be built using widely available components and relatively conventional raster scanning techniques. Multiple interlace and supervertical scan systems, as well as stroke type character displays may at times offer small advantages in logic cost, but the attendant complexity of the display monitor required results in an overall cost penalty.

FIGURE 1

TYPICAL CHARACTER FORMAT



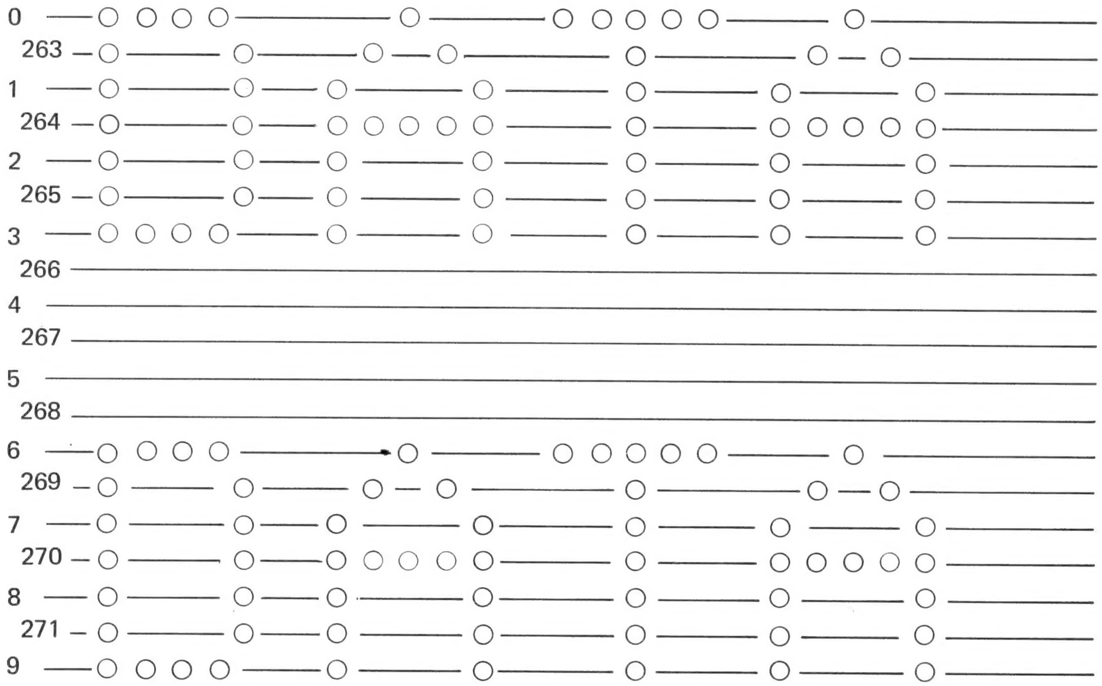
A. Lines per block = 10
B. Total blocks = 24
C. Total active lines = A x B = 240
D. Vertical blanking = 22 lines
E. Active & blanking = C + D = 262 lines
F. Vertical refresh rate = 60 Hz
G. Horizontal frequency = E x F = 15720 Hz
H. Characters per line = 80
I. Width of horizontal retrace in character times = 20
J. Total characters per line = H + I = 100
K. Character frequency = G x J = 1.572 MHz (period = 636 nSec)
L. Dots per character, active 4 spacing = 7
M. Dot frequency = K x L = 11.004 MHz

FIGURE 2

INTERLACED SCAN FORMATS

Below, character array begins on even line, each row of characters

line number

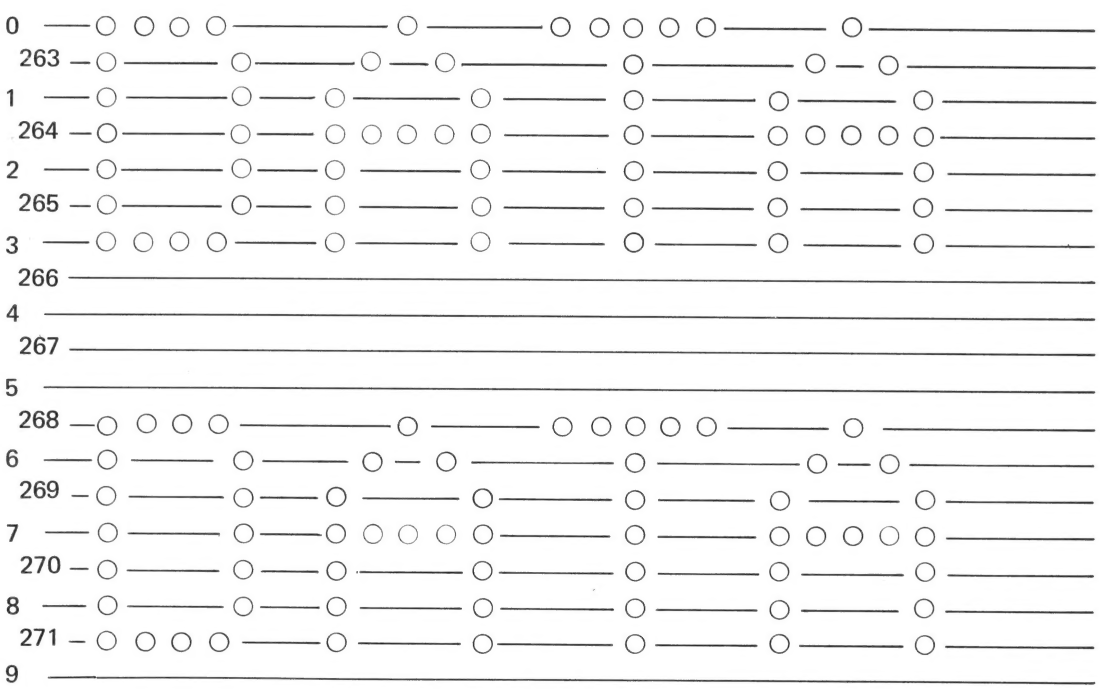


Relative beam current, field No. 1 = 68
Relative beam current, field No. 2 = 54

Beam current unbalanced between fields

Small changes in rastor size will result between fields due to different loading of CRT anode voltage supply between fields. Result will be tearing of characters

Below, character array begins alternately on even and odd lines, row to row.



Relative beam current, field No. 1 = 61
Relative beam current, field No. 2 = 61

Beam current tends to be identical field to field

FIGURE 3

DOT DUTY CYCLE

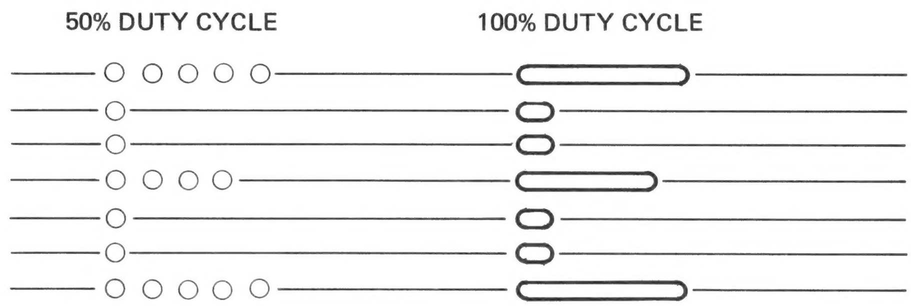
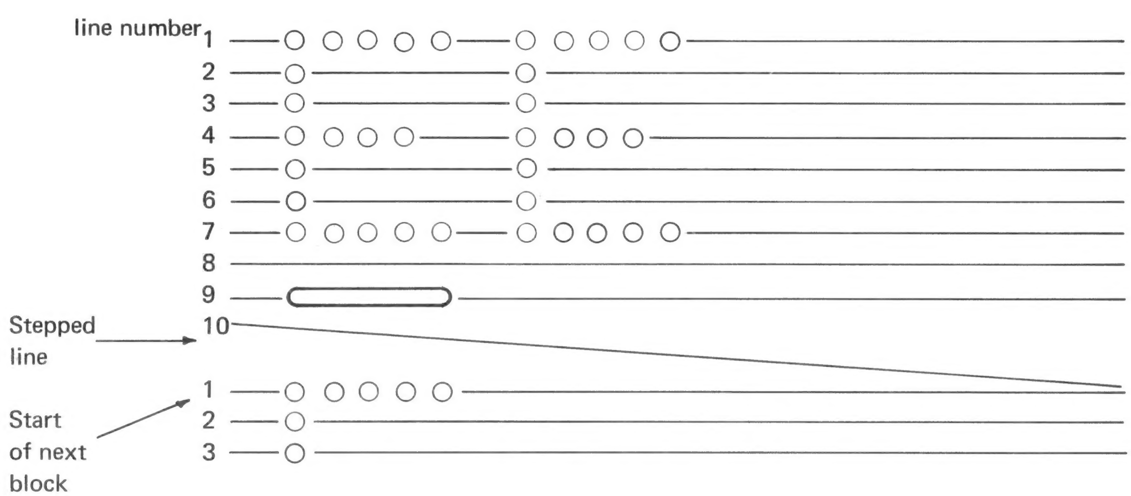


FIGURE 4

STEPSCAN™



APPLICATION NOTES

CHARACTER DISPLAY FORMATS

The following description assumes that the display will have high speed scanning from left to right in the horizontal direction and low speed scan from top to bottom in the vertical direction.

The term CHARACTER BLOCK is used to describe the total number of horizontal dots in a generated character plus the number of blank dots between characters. In the vertical direction, the term character block indicates the number of scan lines required to generate a character plus the blank scan lines between rows of characters.

CHARACTER RATE is the dot frequency divided by the actual dots per character. The dots per character determine the number of horizontal dots in a character block.

CHARACTER TIME is the reciprocal of the character rate.

The actual video period in a horizontal line is the total time of active character locations displayed on each row.

HORIZONTAL SYNC DELAY is the number of character time delays before horizontal sync. This interval is commonly called the "front porch". HORIZONTAL SYNC is the width of the horizontal sync pulse and should be defined in character times.

HORIZONTAL SCAN DELAY is the character times delay after horizontal sync prior to active scan. This interval is commonly called the horizontal sync "back porch".

The sum of the horizontal sync delay, horizontal sync and horizontal scan delay is the HORIZONTAL BLANKING INTERVAL. This interval is required as a window in the horizontal scan period to allow retrace. The RETRACE time is internal to the CRT monitor; this time is a function of monitor horizontal scan components. This time, at a minimum, is the time it takes the display to return from the right to the left-hand side of the display. The retrace time is less than the horizontal blanking interval. Horizontal blanking time is normally about 20% of the total horizontal scanning period.

A practical system is to use a minimum of 25% of the characters per row for horizontal blanking (or approximately 20% fo the character times per row). In an 80 character per row system this would give a total of 20 characters times for the sum of the two delays plus sync. For systems operating at a horizontal scanning frequency of 15750 Hz (63.5 μs period), RS170 compatible signals would be:

Characters (Per Row)	80
H. Sync Delay	04
Horizontal Sync	08
H. Scan Delay	08
Char. Times/Row	100

This approximate ratio of 1:2:2 for the horizontal blanking interval can be used for other characters (per row) settings as follows. (The preferable horizontal retrace time which would enable any system to be compatible with a wide variety of monitors would be in the range of 10.5 to 12 μSec, which is widely used in the industry.)

Characters (Per Row)	H. Sync Delay	H. Sync	H. Scan Delay	Total Character Times/Row
20	1	2	2	25
32	2	3	3	40
40	2	4	4	50
64	3	6	7	80
80	4	8	8	100
99	5	10	10	124

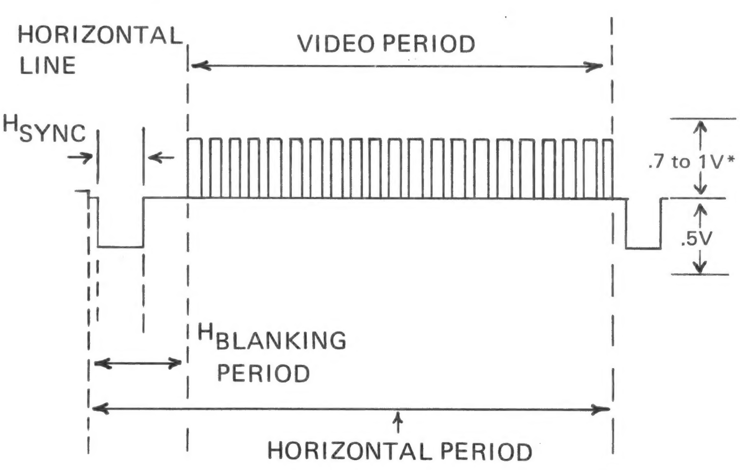


Figure 1. A Composite Video Signal

*Video Amplitude: A 1.5V P/P video signal is typical and is preferred, but any signal from .5V P/P to 2.5V P/P with the same ratio as 1.5V P/P signal is usable.

HORIZONTAL PERIOD (For 15720 Hz horizontal frequency)

$$H_T = \frac{1}{15720} \text{ Hz} \quad 63.6\ \mu\text{Sec}$$

HORIZONTAL BLANKING PERIOD

(Approximately 20% H_T)

$$H_{BLANKING} = (.20)\ (63.6\ \mu Sec) = 12.7\ \mu Sec$$

VIDEO PERIOD

(Horizontal Period - Horizontal Blanking Period)

$$H_T - H_{BLANK} = 63.6\ \mu Sec - 12.7\ \mu Sec = 50.8\ \mu Sec$$

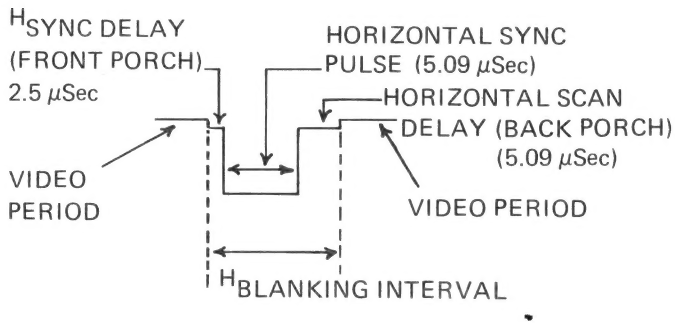


Figure 2. An approximate
Timing of Horizontal Sync Within Horizontal Blanking Period

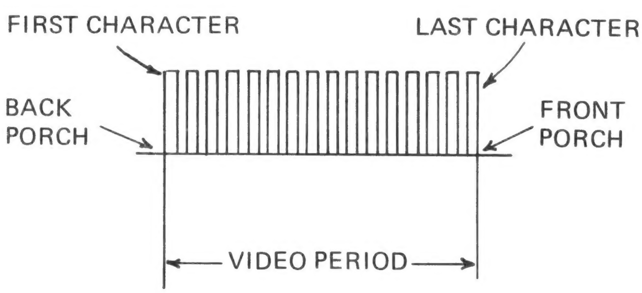


Figure 3.
Timing of Active Video Period Within Video Period.

The required OSCILLATOR FREQUENCY is the desired horizontal scanning frequency times total character times per line times the number of dots per character block.

The VERTICAL SCANNING FREQUENCY can be obtained by the count-down from the horizontal lines. The total number of scan lines generated for a vertical field equals the number of rows times the number of lines per character plus the vertical sync delay plus vertical sync plus the vertical scan delay.

LINES/CHARACTER is the number of horizontal lines in each character block.

ROWS are the number of displayed rows of characters.

VERTICAL SYNC DELAY is the number of scan lines delay before vertical sync.

VERTICAL SYNC is the width of the vertical sync pulse and should be expressed in scan line units.

VERTICAL SCAN DELAY is the delay between vertical sync and the next displayed information in scan line units.

Typical Settings: The sum of the vertical sync and the two delays is the vertical blanking interval. This interval is normally about 5% of the total number of scan lines. For the standard American TV system, the total scan lines in the non-interlaced mode is 262. The vertical scan rate (frame rate) is 60 Hz. Typical settings for evenly spaced non-interlaced patterns are as follows:

Lines/CHR	Rows	V. Sync Delay	V. Sync	V. Scan Delay
10	24	3	3	16
12	20	3	3	16
15	16	3	3	16
20	12	3	3	16

In all the above cases, the total active scan time is 240 lines. In some situations fewer than 240 active scan lines are required, in which case the extra scan lines should be halved and added to both the vertical sync delay and the vertical scan delay.

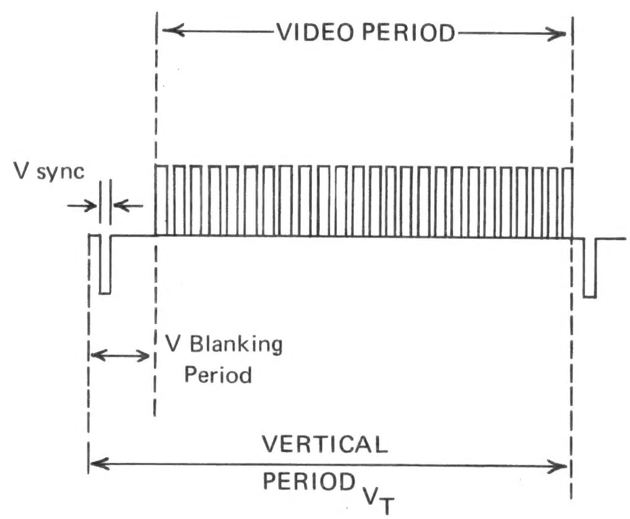


Figure 4. Vertical Field

VERTICAL PERIOD (for 60 Hz Vertical Refresh Rate)

$$V_T = \frac{1}{60\ Hz} = 16.67\ mSec$$

VERTICAL BLANKING PERIOD (approximately 8% V_T)

$$V_{BLANKING} = (.08)\ (16.67\ mSec) = 1.3\ mSec$$

VIDEO PERIOD (Vertical Period - Vertical Blanking Period)

$$V_T - V_{BLANK} = 16.6\ mSec - 1.3\ mSec = 15.3\ mSec$$

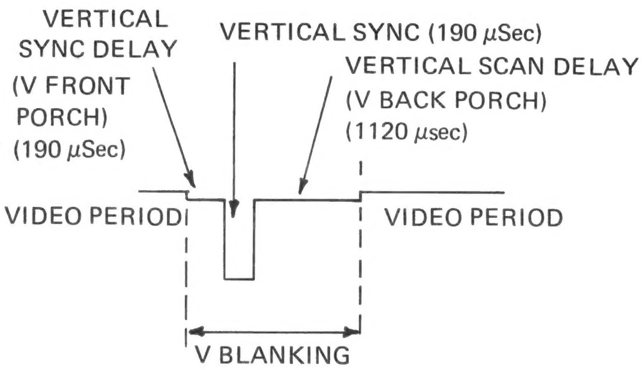


Figure 5.
Timing of Vertical Sync Within Vertical Blanking Period

INTERLACED OPERATION

In the interlace mode of operation two requirements must be met for proper operation.

1. The total number of scan lines must be odd.
2. When an odd number of scan lines per row is set, the number of rows must be even.

For the standard American TV system, the total scan lines in the interlaced mode is 525. In the interlaced mode the vertical scanning is offset by a half line in successive scans (fields).

In the interlace mode of operation, it is desirable to provide at least three scan lines delay before vertical sync. This reduces the possibility of the video signal affecting the sync separator circuits in the display device. Typical settings for interlaced 525 line display formats are as follows:

Lines/Row	Rows	V. Sync Delay	V. Sync	V. Scan Delay
11	44	6	6	29
13	36	12	6	39
15	32	6	6	33
17	28	8	6	35
19	24	18	6	45

Note: These suggested formats meet the restriction on odd lines/frame and the odd number of lines/row. For the European TV system (625 line, 50 Hz) if no additional rows of characters are required, 50 counts should be added to both the delay before the delay before vertical sync and delay before vertical scan.

CHARACTER FORMAT WORK SHEET

1. Character Matrix (Columns ____________________
   (
2. (Rows ____________________

3. Character Block (Columns ____________________
   (
4. (Rows ____________________

5. Frame (refresh) Rate ____________________

6. Rows of Characters ____________________

7. Active Scan Lines (line 6 times line 4) ____________________

8. Delay before Vertical Sync (No. of scan lines) ____________________

9. Vertical Sync Width (No. of scan lines) ____________________

10. Delay after Vertival Sync (No. of scan lines) ____________________

11. Total Scan Lines (Line 7+8+9+10) ____________________

12. Horizontal Frequency (line rate) (line 11 times line 5) ____________________

13. Character Rate (line 12 times line 18) ____________________

14. Characters/Rows ____________________

15. Delay before Horiz. Sync. μsec: (Character times) ____________________

16. Horizontal Sync Width μsec: (Character times) ____________________

17. Delay after Horiz. Sync. μsec: (Character times) ____________________

18. Total character times (line 14+15+16+17) ____________________

19. Clock Rate (line 13 times line 3) ____________________

20. Display size ____________________